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Establishment of Natural Ponderosa Pine Regeneration Under Several Levels of Shelterwood Cutting in the Southwest

by Gilbert H. Schubert

Silviculture of Ponderosa Pine in the Southwest 4110
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ESTABLISHMENT OF NATURAL PONDEROSA PINE REGENERATION UNDER SEVERAL LEVELS OF SHELTERWOOD CUTTING IN THE SOUTHWEST

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THE PROBLEM

The apparent inability to get adequate natural ponderosa pine regeneration when and where needed has been frequently cited to be one of the main problems of timber management in the Southwest. Since 1900, only the 1914 and 1919 seedling crops have restocked appreciable areas in Arizona and New Mexico. During these 2 years most of the unstocked areas within seeding distances of an adequate seed source were restocked. Some areas were also regenerated in 1908, 1929, 1937, 1943, and 1946, but the amount and the regional distribution were less impressive.

An examination of the present age-class composition of southwestern forests indicates that natural regeneration has occured, more or less fortuitously, at irregular but rather long intervals. The general lack of regeneration since 1919 is a matter of record. At least a half million acres of commercial timberland are presently unstocked or poorly stocked. A similar pattern of infrequent natural regeneration prior to 1900 is indicated by the shortage of trees in the 10- to 20-inch classes on several million acres.

Past records also indicate that regeneration problems vary in different parts of the Southwest. The preponderance of evidence seems to indicate a serious regeneration problem over most of the commercial timberland of Arizona and New Mexico. On the other hand, there is evidence that the regeneration problem may not be serious on some parts of the Coconino, Kaibab, and Sitgreaves National Forests, and perhaps other areas. No survey has been made to indicate specific locations with a high probability for natural regeneration.

Many factors, both climatic and biotic, may influence natural restocking. Therefore, it is necessary to identify these factors and determine what modifications are needed in silvicultural practices, supplemental cultural activities, and protective measures to develop good specifications to regenerate commercial timberland in the Southwest. To develop these specifications will require research studies at several locations in Arizona and New Mexico. The study on the Long Valley Experimental Forest will be designed to develop specifications for areas with a similar set of environmental and manipulative factors.

PAST EXPERIENCE

BY REGION 3 PERSONNEL

During the past 60 years no specific efforts have been made on National Forests to obtain natural regeneration. Until recently, timber harvesting has been primarily to salvage anticipated mortality or to improve growing conditions and timber quality of residual trees.

Some areas have received heavy cuts where natural restocking may have been possible except for the practice of seeding to grass and grazing by domestic livestock.

BY STATION PERSONNEL

Other than the 1913 trials at the Coulter Ranch plots near Flagstaff, no specific studies to obtain natural reproduction have been conducted by research personnel. The Coulter Ranch study failed to show conclusive differences between treatments. Several reproduction cutting treatments were tested; however, seedlings from the heavy 1914 and 1919 crops were about equally distributed over all treatment plots.

FROM ANALYSIS OF 1919 SEEDLING CROP

Conditions that prevailed before and after the 1919 seedling crop were reported in Agricultural Monograph No. 6 "Management of Ponderosa Pine in the Southwest" by G. A. Pearson. In general the forests were described as open and parklike. The grass in the "openings" had been severely overbrowsed for many years prior to 1918 by cattle and sheep so competition for moisture was low. Following depletion of the ranges, the number of livestock were drastically reduced.

Southwestern ponderosa pine seeds were found to be unique in their heat requirement for germination. Whereas ponderosa pine from other regions would germinate at low temperatures, the southwestern variety would not germinate until the average temperature exceeded 55° F. Normally temperatures in the Southwest do not average 55° F until early June. By then surface soil moisture is too low for germination. Usually it is July, when the summer rains begin, that both moisture and temperature are favorable for seed germination. In 1919 the May temperature averaged about 6° F higher than normal and about 3 inches of rain fell during the last week. This resulted in early June germination followed by heavy rains in July and August for rapid seedling growth. The seed crop in 1918 was reported to be exceptionally heavy throughout the Southwest.

From the analysis of these conditions, Pearson indicated the requirements for natural regeneration to be:

1. A large supply of good seed
2. On a well-prepared seedbed
3. Free of competing vegetation
4. A low population of seed-eating pests
5. With sufficient moisture for early seed germination and seedling growth
6. Protection from browsing animals and certain insect pests

Although these six main requirements are known, the difficulty has been to get them all to coincide when and where needed. Most of these requirements were met at least to some degree in 1919, but have not been met except in a few locations since then.

All but two of these requirements can be created through cultural and protective measures. These two are seed supply and precipitation.

However, even these two requirements may be met at least partially by some manipulation. For example, regeneration cutting, seed protection, and site preparation can be tied in to good seed years.

Pearson estimated it would require about 200,000 seeds to produce a needed 2,000 seedlings per acre for adequate stocking. For ponderosa pine it means the trees would have to yield about 20 pounds of seed per acre. He also indicated that a large ponderosa pine of at least 20 inches in diameter could produce about 2 pounds of seed during a good seed year and 3-4 pounds during a bumper seed year. Based on these estimates, it would require about 10 trees during a good seed year and 5-7 trees during a bumper seed year to produce the 200,000 seeds. Good seed crops have occurred at intervals of 3-4 years while bumper crops occurred at less frequent intervals.

The second requirement was that the seeds fall on a well-prepared seedbed. A good seedbed consists of loosened soil, which will permit a light layer of soil to cover the seed and has sufficient dead litter to reduce excessive loss of soil moisture. Both of these requirements favor seed germination and seedling establishment. Absence of litter may be compensated for in part by shade cast from the seed trees. Too heavy litter or too dense shade may lower soil temperature and thus retard germination.

The third requirement is that the area be free of competing vegetation. In the Southwest, as in many other parts of the West, soil moisture is one of the main limiting factors that prevent seedling establishment. Usually this requirement will be fulfilled if the area has been adequately treated to provide a well-prepared seedbed. If vegetation reinvades the area before the seedlings are well established a followup chemical treatment may be needed to kill the competing grass or brush.

Adequate site preparation may not assure a low population of seed-eating pests, although the treatment may help to reduce the population. The most common of these pests is deer mice, but other species of mice, chipmunks, squirrels, and birds may be present in sufficient numbers to consume most of the seeds. On areas that were covered with grass, grubs and cutworms are often quite abundant. These insects can cause heavy seedling mortality. Generally some form of rodent control will be required on all areas and insect control may be needed on some areas.

The fifth requirement was for sufficient moisture for early seed germination and seedling growth. Site preparation measures will help to make more moisture available in the deeper soil layers. However, for the seed to germinate it must be kept continuously moist. Frequent rains are essential. Seed that is buried up to a half inch in soil or has a protective litter cover does not require as frequent rewetting as seed exposed on the soil surface.

The final requirement for protection from browsing animals and certain insect pests starts shortly after the seed germinates and may last through the following 10-15 years. Cattle and sheep must be excluded from all regeneration areas for at least the first 5 years and possibly as long as 10 years. The seedlings may also need protection from deer, elk, and tipmoths. If damage occurs the seedlings can be treated with deer repellents or insecticides to protect the young trees.

THE STUDY

GENERAL

The study will be located in the NW$\frac{1}{4}$ of Section 36 of the Long Valley Experimental Forest. The forest within this area consists of even-aged groups of reproduction and sawtimber. These groups vary in size from less than a quarter acre to over 10 acres. Some of the reproduction groups have scattered large trees that occur as singles or 2- to 3-tree groups. Whereas, patches of young reproduction also occupy small areas in some of the sawtimber groups. The ground cover in these groups varies by the tree stocking density. The lowest density groups have a grass cover while the highest density ones have a pine needle litter of variable depth.

All sawtimber groups in this quarter section will receive a partial cut. The sawtimber groups needed for the natural regeneration study will be cut by the two-step shelterwood method to different levels of seed-tree stocking. The first cut will remove all trees not needed for seed trees. The second cut will remove seed trees after reproduction is established. Each of these levels-of-seed-tree plots will be subdivided into several site preparation subplots.

The regeneration area will be marked for the shelterwood cut in 1966 or 1967. If the area has sufficient suitable sawtimber groups, a second complete set of plots will be marked for cutting to provide a rerun of the entire study a year or two later.

Sawtimber groups not suitable for study plots will be clearcut and the area regenerated immediately by seeding or planting. These groups marked for clearcutting would be ones where all the trees are unsuitable for growing stock (broken tops, completely deformed, or partly dead) or are severely infected with red rot or dwarfmistletoe. A preliminary survey made in 1964 indicated only a few groups that should be clearcut for sanitation and salvage.

Isolated mature and overmature trees on areas adequately stocked with advance reproduction will be marked for cutting during the initial cut. Many of these isolated trees are covered with dwarfmistletoe and are suppressing growth on good quality saplings and small poles.

OBJECTIVES

General objective: To determine silvicultural and other treatments needed to obtain adequate and prompt natural regeneration when and where needed.

Specific objectives:

1. To compare seedling densities in relation to: (a) Amount of overwood, (b) method of site preparation, (c) amount of seedfall, and (d) method of seed coverage.

2. To compare proportion of area stocked in relation to: (a) Amount of overwood, (b) method of site preparation, (c) amount of seed distributed, and (d) method of seed coverage.

3. To determine the method or combination of methods that will result in an initial stocking of at least 2,000 seedlings per acre.

4. To determine the various problems associated with site preparation treatments.

5. To compare seedling losses during seed tree removal in relation to basal area of seed trees harvested after initial establishment of reproduction.

METHODS

GENERAL DESIGN

The study will have a randomized block design for seed-tree treatments with a split plot for site preparation treatments, seed levels, and seed coverage. The four blocks will be laid out on the basis of homogeneity of stand density, site, aspect, and slope. Each block will cover an area of about 20 acres to provide at least a 2-chain buffer or isolation strip around each seed-tree level plot.

Each block will be subdivided into four seed-tree level plots of about 4 acres each, exclusive of the buffer strips. Seed-tree level treatments will be assigned at random within blocks. The study will have 16 plots (4 replications of 4 seed-tree levels).

Each seed-tree level plot will be split into 4, approximately equal, site preparation subplots of about 1 acre each. The four site preparation treatments will be assigned at random to each seed-tree level plot. The study will have 64 site preparation subplots (4 replications of 4 plots with 4 subplots each).

Each site preparation subplot will be divided into 4 approximately equal 1/4-acre seed-level subplots. The four seeding levels will be assigned at random to the seed-level subplots. The study will have 256 seed-level subplots.

Each of the seed-level subplots will in turn be split into two soil scarification units. One of the units will be scarified after seeding while the other will be left unscarified. Assignment of the scarification treatment will be at random. These minor subplots (a total of 512) will be used as the smallest sampling unit.

Each of the sampling units will have 10 permanently marked circular milacre quadrats. Seedling counts will be restricted to these 5,120 milacre quadrats which will be randomly located within each sampling unit. Temporary quadrats may be added at a later date if needed to provide more information on seedling distribution.

The boundary lines of the sampling units will be about 5 feet inside the seed-level subplot boundaries. This 5-foot strip will serve as a buffer strip between adjacent subplot treatments where there may be an intermixing of treatment effects.

If several distinct ground cover conditions are evident after installation of site preparation treatments, the area may be stratified and quadrats randomly located on a proportional basis to each stratum.

PLOT ESTABLISHMENT

Seed-Tree Level Plots

After the areas have been selected for the four replications, the procedures listed below should be followed for each block:

1. Prepare a sketch map of the sawtimber groups to approximate scale.
2. Determine dimensions and area of each sawtimber group.
3. Select areas which are at least 4 acres, exclusive of buffer strips.
4. Examine areas for homogenity and then select the four most uniform with respect to stand density and ground cover.
5. Flag boundaries and determine acreages.
6. Assign seed-tree level treatment to the four plots within each replication (block) at random.
7. Select seed trees, mark with white plastic flagging, measure and record diameters. (Follow guides under seed-tree specifications.)
8. Calculate basal area in seed trees.
9. Adjust marking by either cancelling or adding more seed trees until basal area is within ±2 square feet of assigned basal area level.

10. Paint white band on all seed trees.

11. Make tally of all trees on plot to be cut.

12. Take "before cutting" photos from southwest corner of plot.

13. Repeat same procedure for the other three replications.

14. Cut all unmarked trees on study plots. Happy Jack District personnel will handle all aspects of timber sale in the 160-acre natural regeneration area. Station personnel will specify guidelines on timber cutting, protection of area and seed trees, and will supervise work to insure compliance with treatment prescriptions.

Site Preparation Subplots

The following procedure will be followed to split each seed-tree level plot into four site preparation subplots:

1. Examine sketch map prepared for plots under procedure above.

2. Divide plot into approximate 4 equal subplots of 1 acre each.

3. Mark subplot boundaries on ground. A row of yellow 2-inch by 2-inch stakes can be placed to mark line between adjacent subplots.

4. Assign the four site preparation treatments at random and show on sketch map.

5. Locate temporary photo points (blue stakes) in southwest corners and approximate subplot centers (white stakes).

6. Take black and white (4x5) and color (35 mm) photos from photo point to subplot center for each subplot. Record data for

each photo. (A blackboard, properly labeled and set so as to appear in the lower right corner of the photo, would aid in identification of the specific treatment.)

7. Repeat same procedure to subdivide each of the other seed-tree level plots.

8. Site preparation will be done by Happy Jack personnel as scheduled.

9. Following completion of site preparation treatments, subplot boundaries, photo points, and subplot centers will be reestablished as needed.

Establishment of Seeding Subplots

1. Divide each site preparation subplot into 4 approximately equal units.

2. Show boundary lines on ground and on site preparation sketch map.

3. Assign at random one of the 4 seeding rates to each unit.

4. Broadcast seed at prescribed rate. Seed must be sown uniformly over plot in two or more passes at right angles to preceeding pass. Avoid sowing seed into adjacent units.

Establishment of Scarification Units

1. Divide each seeding subplot into 2 equal units.

2. Select one at random for soil scarification treatment after seeding.

Location of Quadrats

1. Mark boundary of "sampling area" within each scarification unit. The sampling area is to include all of the unit except a 5-foot wide buffer strip around the outer edge. The line need not be marked on the ground, but should be understood to follow a line approximately 5 feet inside the exterior edge of the unit.

2. Establish grid, with lines spaced 10 feet apart, on sampling area and then select 10 random points from the approximately 40 points for quadrats.

3. Mark each quadrat location with a red wooden survey stake. Top of stake to be about 4 inches above ground level.

4. Nail a numbered tag (from 1 to 10) on top of each stake for identification. Number stakes in order beginning in southwest corner. Mark tags on scarified unit with an "S" in addition to number.

5. Repeat same procedure to locate quadrats in all other sampling units.

Boundary and Treatment Signs

1. "Experimental Area Boundary" signs will be posted at about 200-foot intervals around exterior boundary of the natural regeneration unit of 160 acres. These signs will face toward the study area.

2. A sign "Natural Regeneration Study Plot" will be erected at each road entrance to the study area.

3. A sign will be posted on each subplot to show: (a) Block number, (b) seed-tree level, and (c) site preparation measure. For example,

BLOCK NO. 1

10 SQ. FT./A.

CHEMICAL

4. A sign indicating seeding level will be placed in the center of each seeding subplot.

5. Following plot establishment, a sketch map will be prepared to show boundary and treatment designation of each bock, plot, and subplot for inclusion in the establishment report (see Appendix).

TREATMENT SPECIFICATIONS

Treatments are designated as (1) main, (2) other, and (3) seed tree removal. The main treatments are those applied specifically to designated plots and subplots, for example, seed tree levels, site preparation measures, seeding rates, and seed coverage. All other treatments are applied uniformly to all parts of the study.

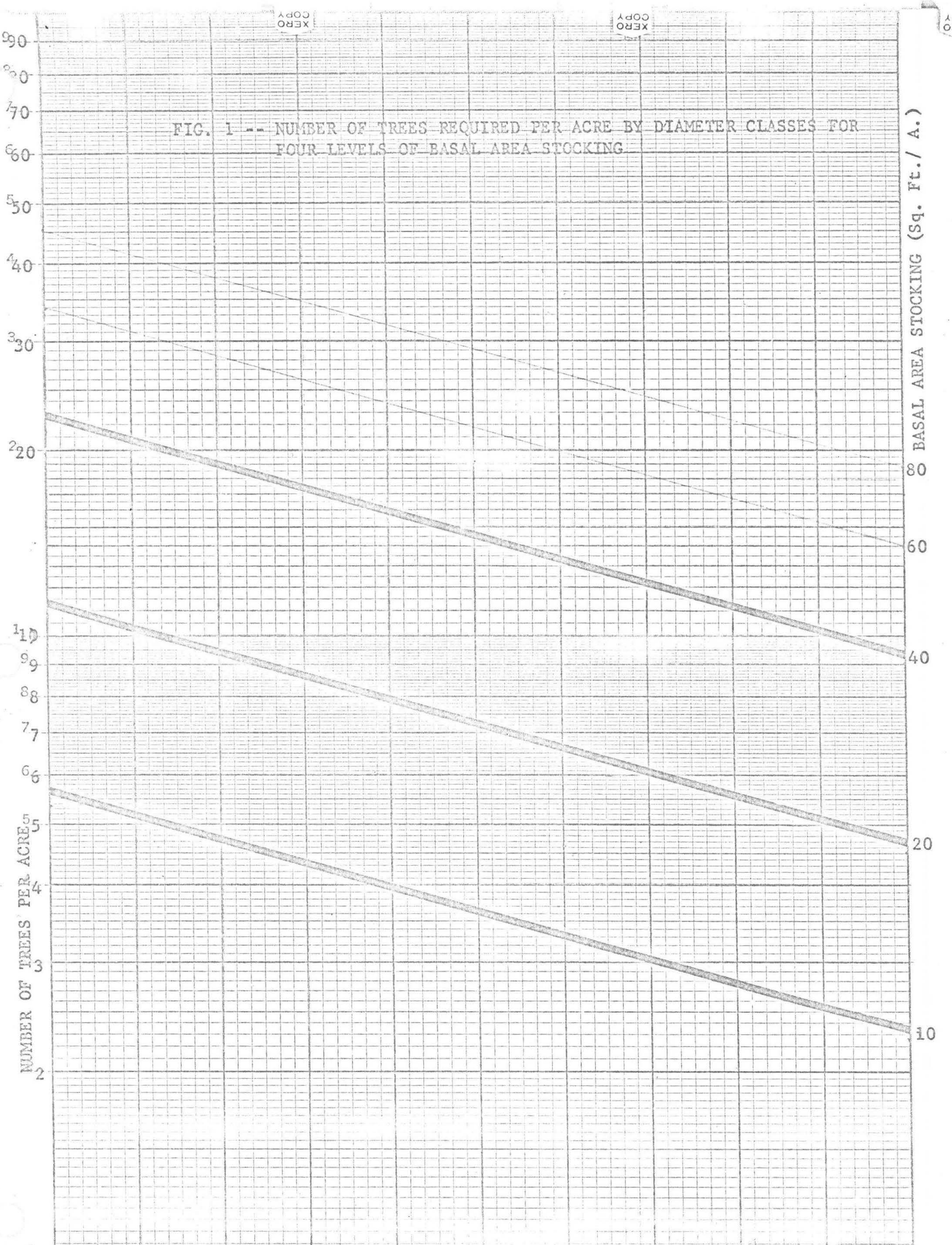
A. Main Treatments

1. Seed-Tree Levels

Four levels of seed trees will be tested--0, 10, 20, and 40 square feet of basal area per acre (fig. 1). The number of trees within any

(text continued on page 16)

FIG. 1 -- NUMBER OF TREES REQUIRED PER ACRE BY DIAMETER CLASSES FOR FOUR LEVELS OF BASAL AREA STOCKING



15a

one basal area level will vary depending on the contribution of trees within each diameter class. The greatest number of trees will be retained if they are all 18 inches d.b.h. and the least if they are all 28 inches or larger. The contribution of trees between these diameter extremes will change the number of trees required for a specific basal area.

The median level of 20 square feet basal area will leave about the same number of seed trees recommended earlier by Pearson. The other 3 levels will provide a test at a stocking that may be near the lower and upper limits. These four levels will also provide some measure of shade and root competition effects on seedling establishment in addition to the differences in seed production.

Seed tree levels related to basal areas have several distinct advantages over "numbers of trees." Seed production was shown to increase with tree size in California.[1] Therefore, seed production would be positively correlated with tree size. Similarly crown size and root systems would increase with an increase in tree size. Thus shade and root competition effects would increase as the tree size increases. Consequently, if the levels are based only on number of trees, the effect of seed production, shade, and root competition would be confounded by tree size. Seed tree levels geared to basal areas would minimize the confounding effect of tree size.

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[1] Fowells, H. A. and Schubert, G. H. Seed crops of forest trees in the pine region of California. U.S. Dept. Agr. Tech. Bul. 1150. 1956.

Most trees selected for seed trees will range from 20-24 inches in diameter. If sufficient trees within this range are not available, 18- and 26-inch trees may be left. Trees less than 18 inches or greater than 26 inches should not be retained except if absolutely necessary.

Basal areas retained in seed trees will be within ±2 square feet of the prescribed level (table 1).

1a. Seed Tree Specifications

Seed tree selection will be governed by the following criteria:

(1) Size--20-24 inches in diameter.

(2) Crown class--dominant but may be a good codominant if suitable dominant not available.

(3) Vigor--good, without dwarfmistletoe or other disease.

(4) Good cone producer--many old cones under the tree.

(5) Tree form--straight, unforked, with moderate taper.

(6) Crown form--well developed and fine branched with at least 50 percent of tree height in live crown.

(7) Spacing--trees well spaced to provide adequate seed coverage for area.

(8) Number of seed trees per acre--variable, depending on tree size and specified stocking level. If necessary, seed trees may be

Table 1.--Basal area of trees by diameter classes

D.b.h.	Average basal area
Inches	Square feet
16	1.48
17	1.67
18	1.87
19	2.07
20	2.29
21	2.52
22	2.76
23	3.01
24	3.27
25	3.55
26	3.83
27	4.12
28	4.43
29	4.75
30	5.07

retained outside the plot but within 1-tree height of the plot boundary to provide seed for unavoidable "vacant" areas near the edge of the plot. The number left should not exceed the number required for the enlarged plot with same basal area per acre.

The above specifications will serve as a general guide to select the best seed trees. Some areas may have too few good seed trees. If the specifications must be lowered too much to leave the required stocking, a new plot location should be selected.

2. Site Preparation

Seedbed preparation on study plots will be either chemical, mechanical, combination fire-chemical treatment, or control. Each treatment should be as uniform as possible over entire subplot. All advance pine reproduction on subplot will be cut and disposed of in same manner as other slash for the treatment.

(a) Chemical Treatment

Since grass is the predominant competing vegetation, the chemical treatment will consist of 5 pounds of dalapon per acre applied as a water solution with a power sprayer in July or August of a nonseed year. Enough water should be used to give good coverage at the 5-pound rate per acre. Precise calibration is not essential as it is more important to get complete grass coverage with dalapon than to leave part of the area untreated.

(b) Mechanical Treatment

Mechanical site preparation will be done with a bulldozer or brush rake (brush rake preferred if available) after the summer rains. The ground surface should be disturbed sufficiently to uproot vegetation but not injure roots of seed trees. It is not necessary to windrow the uprooted grass or other competing vegetation unless needed to control erosion.

(c) Fire-Chemical Treatment

The fire-chemical treatment consists of a chemical spray followed by a broadcast burn. All slash will be lopped and the area burned whenever safe following logging. The fire need be hot enough to burn only the pine litter and small branches of the slash. A fireline will be constructed around the outside edge of the subplot and all slash pushed well within the area to be burned. The chemical treatment will be the same as on the chemically treated plots above.

(d) Control Treatment

Under control treatment, no special or extra site preparation will be done other than that which occurs during logging. This treatment will provide a comparison of seedling densities that would be expected from a regeneration cut without additional seedbed preparation with seedling densities on areas that received extra cultural work. A considerable amount of soil disturbance will occur on each of the seed-tree level plots. Because of expected differences in timber volumes removed under the three levels of residual seed trees, differences may be expected in the amount of soil disturbance. Comparison of seedling densities on a seed-tree level basis may show significant differences resulting in part soil disturbances on control plots.

Comparison of seedling densities on plots will indicate how much or little extra efforts are required to prepare seedbeds for adequate restocking to ponderosa pine.

(e) Slash Disposal (considered to be part of the site preparation treatment)

All logging slash on the study subplots, except the fire-chemical and "control" ones, will be machine piled and burned. Slash on fire-chemical subplots will be lopped and broadcast burned. Slash on the control subplots will be lopped and scattered. Slash piles must be compact and located to avoid heat damage or destruction of the seed trees. Slash should not be piled so high that the flames will scorch the trees. Small patches of advance reproduction within the plot boundaries will be destroyed.

3. Broadcast Seeding

Seed in this study will be broadcast sown rather than depend on natural seeding. Broadcast seeding has several distinct advantages over natural seeding with no serious disadvantages. Some of these advantages are:

1. "Natural" seeding studies can be conducted when and where needed. There is no need to wait for a "good" seed year.

2. Known quantities of seed can be sown. To estimate the number of natural seed falling on an area may require a hundred to several thousand costly seed traps. Many of the problems of getting reasonably accurate and reliable estimates of natural seedfall are avoided.

3. Seed can be distributed uniformly over the study areas. This eliminates the need for sampling and avoids the pitfalls associated with poor seed distribution.

4. Several intensities of seed quantities can be tested on the same area in the same year. With natural seeding, only one intensity may be available for the test.

5. The test of several seeding intensities provides a basis to estimate expected results during light to heavy seed years. With natural seedfall many years of testing may be required for comparable information. It also helps to minimize the differential effects of climate during different testing years.

6. It reduces the possibility of research failures. Many natural regeneration studies failed when the expected seed crops did not materialize or other factors intervened which seriously clouded the results.

7. The research dollar will be more productive with the broadcast than the natural seedfall method. Many of the cost factors involved with natural seedfall are elirinated or avoided.

Many different levels of seeding may be tested; however, there is nothing to be gained by sowing excessive amounts of seed per acre. The maximum seed per acre for this study is set at 8 pounds. This would supply about half of the amount estimated by G. A. Pearson to be required for adequate stocking. Even 8 pounds of seed are prohibitive for direct seeding, but amounts up to 2 or 3 times this may be deposited during a good seed year. Furthermore, since forest lands need to be regenereated during lighter seed years, we need to concentrate more on the biological and environmental factors that destroy seeds and seedlings.

The following rates will be sown:

1. One pound per acre (about 11,000 seeds)
2. Two pounds per acre (about 22,000 seeds)
3. Four pounds per acre (about 44,000 seeds)
4. Eight pounds per acre (about 88,000 seeds)

The preweighed seed for each seeding subplot will be divided into two nearly equal lots. The second lot will be sown at right angles to the first.

It may be advisable to sow the lowest rate at each location first and then progress to higher rates. The seed should be sown before quadrat stakes are set out to avoid a tendency to concentrate seed on any specific location.

If seed supply is limited, the quadrats may be laid out first and the seed sown only on the specific milacres in study. The extra seed, if any, could then be sown at a lower rate over the other portions of the plot.

B. Other Treatments

1. Rodent Control

The natural regeneration area of 160 acres will be treated with "1080" poisoned oats.[1] The poison bait will be placed in spots at a rate of about 80 per acre except for the first 200 feet inside of the area boundary, which will be baited with 160 spots per acre. About 1 quart of bait is required for 80 spots. The bait should be placed along logs, rocks, stumps, or other material in such a manner that the bait is readily accessible to rodents but not to birds and other wildlife. Do not place bait on logs, stumps, rocks, or other exposed surfaces.

The area will be baited at three different dates. The first baiting will be done in the fall about 1 week before seeding. The second baiting will be done about May 1 and the third about June 30.

Personnel from the U.S. Fish and Wildlife Service at Phoenix will treat the oats with "1080" or other designated chemical and supervise the baiting and area posting.

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[1] Endrin or DRC-714 treated oats may be substituted for the "1080" treatment if tests with these chemicals in New Mexico are successful. Neither of these chemicals have the secondary poisoning effect of "1080".

2. Livestock Control

A 3-strand barbed-wire fence will be constructed around the entire Experimental Forest following logging in 1965. Cattle will be excluded from the regeneration areas during the period of seedling establishment. This exclosure period will begin in the fall of a good seed year and end when the young trees are out of trampling and browsing danger. The total exclosure period will probably be at least 5 growing seasons and may be up to 10 seasons.

3. Deer and Elk Control

If deer or elk browsing damage is serious, seedlings will be treated with a repellent. Date of application, kind of chemical used, and duration of treatment will be based on research results of studies conducted at the Fort Valley Experimental Forest.

C. Seed Tree Removal

Seed tree removal will depend on the adequacy of seedling stocking and future research needs. Differences in seed tree levels and site preparation measures may result in large differences in stocking densities. For a plot to be adequately stocked, it should have about 2,000 well-distributed seedlings per acre. Stocking on some or all plots may equal or exceed this density. On the other hand, some or all may fall short. Even though all plots may be adequately stocked, it may be considered necessary to repeat the study on the same plots during another year when environmental conditions may be different.

Unless amended, the study will be conducted as described under conditions of adequate and inadequate stocking.

1. Adequate Stocking

All seed trees will be removed when the seedlings average about 1 foot in height. The study will then be terminated following analysis and publication of results.

Care must be exercised in harvesting the seed trees to avoid all unnecessary damage to the seedlings. Trees will be felled to minimize the amount of area disturbed. Logs will be snaked out by cable and skid trails kept at a minimum. Slash will be lopped and scattered. Care must be exercised to avoid unnecessary piling of limbs on young trees. Damaged and destroyed seedlings will be counted on each subplot after completion of logging and slash disposal.

2. Inadequate Stocking

If the study is to be continued, no seed trees will be cut. All site preparation and control measures will be repeated and the study rerun.

If the study is to be terminated, seed trees will be cut only from plots with adequate stocking and the others will then be re-treated during the next seed year. Or, all seed trees will be cut and the plots with inadequate reproduction will be planted.

MEASUREMENTS

Seedling counts will be the main kind of data collected. The seedling data will come from periodic tallies of seedlings on 5,120-circular-milacre quadrats.

Additional milacre quadrats or line transects may be installed if needed to furnish more data on seedling distribution. Temporary quadrats may be located on grid points not used during randomization of the permanent quadrats or may be located in void spaces not adequately covered by permanent quadrats.

Seedling mortality will also be counted and recorded by cause if known. Mortality data will not be complete but may be sufficient to identify main causes and needs for separate study.

A. Seedling Counts

Seedling counts will be made at the times listed below as well as other times to record unusual events. An entry will be made on the "Record of Seedling Inventory" form for each quadrat. The quantity will be entered as a two-digit number. If no seedlings are present, show it as "00."

The recorder will date and initial the appropriate column for each measurement period. The measurement schedule is as follows:

1. End of August of the first summer following establishment of study. These data will show how many seedlings got started.

2. Late October or early November of the same year. This will provide a measure of early seedling losses during the first fall drought period.

3. Early May of second year to determine winter losses.

4. Early June of second year to determine losses during first spring drought.

5. Annual count each fall until study is closed.

6. A week before and after seed tree removal.

B. Mortality Counts

The main mortality record for this study will be that caused during harvesting the seed trees. However, mortality caused by other factors will be recorded when the cause is apparent. Mortality will be recorded on the "Record of Seedling Inventory" form as a three-digit number. The first two digits will indicate the number of dead seedlings. The third digit will indicate the causal agent. If losses on any one quadrat are caused by more than one factor, record the one that killed the most seedlings. The code number for causual agents are:

0 - Logging
1 - Drought
2 - Heat
3 - Frost
4 - Insects
5 - Disease
6 - Rodents
7 - Deer or Elk
8 - Rabbits
9 - Unknown

Mortality counts will be made at each measurement date. The logging mortality inventory may be a special measurement if the trees are cut during the summer or will be part of the fall inventory if the trees are cut in late September or October. The logging mortality inventory will require two examinations of the quadrats. In the first inventory, record the number of live seedlings just before logging in the "Seedling" column. Then fill in the "Mortality" column when the plots are reinventoried after logging and slash disposal are completed.

By the time the plots are ready for seed tree removal, mortality from other causes should be negligible. However, if considerable mortality did occur since the last measurement, the inventory just prior to logging should be completed for both "Seedlings" and "Mortality." Then use the columns for the next measurement period for the logging "seedling" and "mortality."

PHOTOGRAPHIC RECORD

Before and after treatment photographs, both 35 mm color and 4x5 black and white, will be taken at specified photo points. Black and white photos will be taken of each subplot. Color photos will be taken only of one complete set of seed tree level plots and site preparation subplots. The photo points will be in the southwest corner of each subplot and the cameras will be pointed toward the subplot centers.

Photos should be taken to show:

1. Subplots with seed trees marked before and after the stands are cut.

2. Subplots before and after site preparation.

3. Close up action shots of cutting, site preparation, broadcasting seed, inventorying quadrat, and other appropriate scenes.

All photos are to be correctly labeled and filed in the project files. After termination of the study, photos will be transferred to master photo file.

One complete set of color slides, properly labeled, will be sent to the Assistant Director, Timber Management and Protection Research for his I&E program.

COMPUTATIONS

Field data will be converted to the measures listed below. As needed for analyses and summaries, these measures will be on a quadrat, subplot, plot, or per acre basis.

1. Seedling stocking densities by site preparation methods, seeding rates, seed coverage, and seed-tree levels.

2. Frequency distributions of seedlings based on individual quadrats and sampling units for seed tree and sowing levels.

3. Amount of seedling mortality by causal agent.

4. Seedling losses from logging by seed-tree levels.

5. Seed to seedling ratios.

6. Seed viability.

These measures on seedling establishment, seed effectiveness, logging damage, frequency distributions, and other measures will provide valuable information for analysis and interpretations of the results of the study, for clues of needed research, and guidelines to follow in regeneration cuts on National Forests.

STATISTICAL ANALYSIS

Differences in treatment effects will be evaluated by the Analysis of Variance, using average or total values on quadrat or acre basis. Each seeding rate and site preparation subplot and seed tree level plot will provide values of independent and dependent variables. Independent variables to be tested are residual basal areas, site preparation, and seeding rates. Dependent variable will be stocking densities and stocked quadrats.

A. Sampling Units and Transformation

The sampling unit will consist of 10-milacre quadrats (radius = 3 feet 8.7 inches or 3.725 feet) measured on each ground scarification unit of each seeding subplot. The count data for these samples of 10 quadrats will be plotted to determine the type of frequency distribution for number of sampling units with 0, 1, 2, 3, etc. seedlings. If the frequency distribution approximates a normal distribution, the count data will be considered as continuous variables and no transformation needed. However, if the distribution approximates a Poisson distribution, count data will be transformed to angles.

The data will be examined following the first sampling. If the number of sampling units without seedlings are considered to be excessive, each milacre quadrat will be increased to 2 milacres. The radius of a 2-milacre quadrat would be 5.27 feet (5 feet 3.2 inches).

B. Source of Variation

The degrees of freedom for the independent variables in the Analysis of Variance are:

Source of Variation	D.F.	
Replications (R)	3	
Seed-tree levels (B)	3	
R x B (error a)	9	
Total for main plots	15	
Site preparation (S)	3	
S x L	9	
S x R)	9)	
) error b	)	36
S x B x R)	27)	
Subtotal for site preparation subplots	48	

Source of Variation		D.F.	
Seed-levels (L)		3	
L x S		9	
L x B		9	
L x S x B		27	
L x R	error c	9	144
L x S x R		27	
L x B x R		27	
L x S x B x R		81	
Subtotal for seed-level subplots		192	
Seed coverage (C)		1	
C x L		3	
C x S		3	
C x B		3	
C x L x S		9	
C x L x B		9	
C x S x B		9	
C x L x S x B		27	
C x R	error d	3	192
C x L x R		9	
C x S x R		9	
C x B x R		9	
C x L x S x R		27	
C x L x B x R		27	
C x S x B x R		27	
C x L x S x B x R		81	
Subtotal for coverage subplots		256	
Total for study		511	

Nonsignificant third and fourth order interactions will be pooled with the appropriate error variance.

RESPONSIBILITY

The responsibility for the execution of the study, collection and analysis of data, and preparation of the manuscripts will be assigned to Gilbert H. Schubert of the Division of Timber Management Research at Flagstaff, Arizona. E. C. Martin will assist in establishment of plot boundaries, marking the plots for the seed tree cuts, and establishment of milacre quadrats.

M. M. Larson and L. J. Heidmann will assist in the treatment of plots and collection and analysis of data.

The District Ranger at Happy Jack will be responsible for preparation and execution of the timber sale.

TIME SCHEDULE

Plot boundaries--spring 1966.

Mark seed trees--spring 1966.

Cut plots to level--summer 1966.

Site preparation as designated--summer 1966.

Seeding--in fall during normal seedfall.

Location of quadrats--immediately after seeding.

Rodent control--1 week before seeding in fall and repeated on May 1 and June 30 the spring and summer after seeding.

Seedling counts--as indicated under "Measurements."

Germination tests--prior to establishment of study.

Termination of field phase of study--at end of 10th growing season after establishment.

Preparation of reports--at appropriate times during study and after termination of field phase.

AMENDMENTS

All changes in the study affecting treatment results or additions must be approved in advance and made a part of the Appendix of this study plan.

REPORTS

The Timber Management Research Unit at Flagstaff will prepare establishment report, progress reports, and manuscripts for publication. Results will be published as Station Research Notes or appropriate professional journal articles.

ESTIMATED COSTS

Funds

Plastic flagging (4 doz. rolls @ 37¢/roll)	$ 18.00
Stakes (10,000 @ $1.40 for bundle of 25)	560.00
Mileage (8,000 @ 9¢/mi.)	720.00
Seed (240 lbs. @ $4/lb.)	960.00
Photographic film (color)	20.00
Photographic film (black and white)	50.00
Material for signs	50.00
Total	$2,378.00

Manpower

Installation of plots	90 man-days
Periodic measurements	80 man-days
Analysis of data	10 man-days
Preparation of reports and manuscripts	20 man-days
Total	200 man-days

APPENDIX

BLOCK AND PLOT LOCATIONS

Sketch (to scale) of NW$\frac{1}{4}$ of Sec. 36 of Long Valley Experimental Forest showing location of: (1) Blocks, (2) plots, (3) roads, (4) sapling and pole stands, (5) artificial seeding plots, and (6) location of plot signs and markers. Number each block and plot.

PLOT AND SUBPLOT LOCATION AND SIZE

Sketch (to scale) of each plot and its included subplots.

Show the following on each sketch:

1. Seed tree level.
2. Site preparation methods.
3. Boundary of sampling area for each seeding subplot.
4. Location of quadrats (include quadrat numbers).
5. Size (in acres) of each plot and various subplots.
6. Location of photo points and subplot centers.

Form No.____

RECORD OF SEED-SEEDLING INVENTORY Sheet_____ of _____sheets

Location ______________________ Study No. 4110-FS-RM-1203.18

Block No._____(1); Seed-Tree Level ______(2-3); Site Preparation _______(4)

Seed-level ______(5-6)

7-8	9-10	11-13	14-15	16-18	19-20	21-23	24-25	26-28	29-30	31-33	34-35	36-38
	August____		October____		May____		July	____	October____		October____	
Quadrat No.	Number of Seedlings	Mortality	Number of Seedlings	Mortality	Number of Seedlings	Mortality	Number of Seedlings	Mortality	Number of Seedlings	Mortality	Number of Seedlings	Mortality
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02												
03												
04												
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